



BioFuels – Cellulosic and Algal Feedstocks

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DARPA's Expectations: Algal Development

Objectives:

- < \$3/gal JP-8
- < \$2/gal algal oil in Phase 1
- < \$1/gal algal oil in Phase 2

Final Phase 2 deliverables:

- 4,000L bio-derived JP-8 sample
- Qualification plan
- Commercialization plan

Challenges:

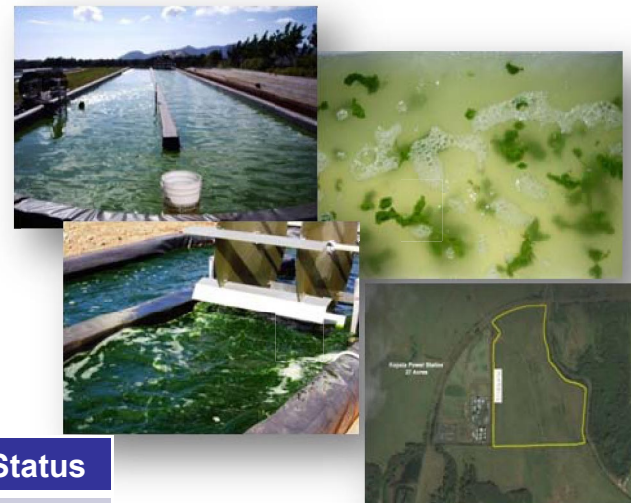
- Further improvement of Phase 2 process technologies to meet the more challenging Phase 2 metrics
- Development and integration of high-risk Pre-Planned Product Improvement (P³I) technologies/paths
- Reduction in CAPEX

Timeline:

- June 2010 – Dec 2011
- Targeting technology scalability demonstrations for algal growth and processing systems

Projected accomplishments at the end of the DARPA Program:

- Algal oil will be between \$1-2/gal
- Oil production ~2,000 - 3,000 gal/acre
- Algal oil conversion to jet, diesel, and gasoline ratios will be controllable:
 - 40% jet
 - 30+% diesel
 - 20+% gasoline
 - Balance = light ends
 - Overall 90+% use rate of algae
- Large feed byproducts will be available



Phase	Technical Area	Phase 2 Program Metrics	Status
Phase 2	Affordable Algal Oil for JP-8	1. \$1/gal triglyceride oil from algae 2. Projected cost of production of JP-8 < \$3/gal at 50 Mgal/yr	TBD



DARPA's Expectations: Cellulosic Development

Objectives:

- < \$3/gal JP-8
- > 30% energy content conversion in Phase 1
- > 50% energy content conversion in Phase 2

Accomplishments to date suggest the following about cellulosic material:

- 50% energy conversion for most feedstocks
→ ~1,000 gal oil/acre
- Lignin fraction is preferably converted to aromatics
- Cellulosic material is a generator of CO₂
- Ideal feedstocks include:
 - Energy cane
 - Energy sorghum
 - Sor-cane
- Cellulosic conversion processes
 - Able to obtain a greater fraction of the target fuel
 - May need additional certifications/approvals

Final Phase 2 deliverables:

- 4,000L bio-derived JP-8 sample
- Qualification plan
- Commercialization plan

Challenges:

- Further improvement of Phase 2 process technologies to meet the more challenging Phase 2 metrics
- Development and integration of high-risk Pre-Planned Product Improvement (P3I) technologies/paths
- Reduction in CAPEX

Timeline:

- September 2010 – February 2012
- Targeting technology scalability demonstrations for cellulosic material conversion and processing systems



Phase	Technical Area	Phase 2 Program Metrics	Status
Phase 2	Cellulosic Material to JP-8	<ol style="list-style-type: none">1. 50% efficiency, by energy, in the conversion of cellulosic material feedstock to JP-82. Projected cost of production of JP-8 < \$3/gal at 50 Mgal/yr	TBD



Outcome Objectives of the DARPA Program



Eliminate/reduce technical risk

- Demonstrate technologies at scales capable of producing the 4,000L fuel deliverables
- Demonstrate technical reproducibility
- Develop better understanding of process control
- Further improve process models

Risks remaining at the end of Phase 2:

- Some technical and business risks may still remain
 - Final mitigation of business risk has to be driven by partners outside of DARPA
 - DARPA has been gathering information from industry partners to understand and help the government buy-down these risks

Demonstrate scalability

- Demonstrate technical scalability by
 - Developing the capacity to produce the 4,000 L JP-8 fuel deliverable
 - Demonstrating the technology set can reasonably be scaled to 50 Mgal jet fuel/year
- Demonstrate business scalability by
 - Achieving cost objectives at a scale <50 Mgal jet fuel/year
 - Minimizing CAPEX requirement; \$50-100M perceived as maximum in current market conditions

Risks remaining at the end of Phase 2:

- Risk of scale up between Phase 2 demonstration scale and OV1 remains; Must be addressed outside of DARPA

Demonstrate qualify-ability

- The initial BioFuels program (crop oils to JP-8) provided a starting point for the fuel qualification process of “drop-in” alternative fuels
 - Use current fuel infrastructure (pipelines, tankage, engines/turbines)
 - Faster qualification/certification
 - No required changes to current fleet of DoD platforms
- The BioFuels – Cellulosic and Algal Feedstocks program provides additional feedstocks to feed in to current qualification process
 - An HRJ fuel qualification will motivate an ASTM certification for non-HRJ fuel which will lag behind by a few years
 - Production of large volumes of cellulosic/algal biofuel for qualification tests

Risks remaining at the end of Phase 2:

- Qualification of HRJ is not expected until 2012 with the qualification of non-HRJ fuels to follow a few years later

Demonstrate commercialize-ability

- Develop mature, robust processes to JP-8
- Develop dynamic cost models to address location driven market differences
- Performers to develop fuel qualification plans and commercialization plans
- DARPA retiring technical risks but business risks will remain

Risks remaining at the end of Phase 2:

- The Phase 2 demonstrations are not pilot scale and will fall short of enabling full scale commercialization

Qualification activities are essential for full transition of the Algal and Cellulosic projects

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